

REPORT OF THE
OFFICE OF THE AUDITOR GENERAL
TO THE
JOINT LEGISLATIVE AUDIT COMMITTEE

814.1

IMPROVEMENTS NEEDED
IN PLANNING AND MONITORING
RESEARCH AND DEVELOPMENT
OF ALTERNATIVE ENERGY SOURCES

NOVEMBER 1978



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The Honorable Speaker of the Assembly
The Honorable President pro Tempore of the Senate
The Honorable Members of the Senate and the
Assembly of the Legislature of California

Members of the Legislature:

Your Joint Legislative Audit Committee respectfully submits the Auditor General's report on the California Energy Commission's system for planning and monitoring research and development of alternative energy sources.

The report identifies opportunities to improve the planning and monitoring of such research activities. To ensure maximum benefits from future resources spent on research of alternative energy sources, Commission planning requires more specific policy direction and development of more definitive project plans outlining quantifiable objectives, time-phased milestones and total estimated project costs. Additionally, the Commission needs to implement a formal system for monitoring (1) research conducted by other organizations and (2) the progress and effectiveness of its own projects.

The Auditor General recommends specific changes to the Commission's systems for planning and monitoring research of alternative energy sources.

The auditors are Harold L. Turner, Audit Manager; Richard C. Mahan; Kathleen A. Herdell; and Peter A. Wolfe.

Sincerely,

RICHARD ROBINSON
Chairman

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SUMMARY

Since its formation, the California Energy Resources Conservation and Development Commission (Commission) has assessed, reviewed and screened numerous research areas to determine which areas California should pursue. At the conclusion of the screening period, the Commission selected primary and secondary priorities for solar, geothermal, fuels and other technologies. Approximately \$14 million has been spent assessing and researching alternative energy sources.

Commission alternative energy research programs have evolved to a level requiring a more comprehensive planning system. While broad policy statements of the Commission's research role, direction and priorities have been identified, the current planning process is insufficient to ensure maximum benefits from future resources spent on research of energy alternatives. Specifically, the Commission's planning requires:

- More specific policy direction to assist staff in prioritizing projects and allocating resources (see page 9)
- Development of project plans identifying the full term of the project, quantifiable objectives, time-phased milestones and total project cost estimates (see page 19).

The Commission also needs to implement a formal system for monitoring research and development conducted by other organizations (see page 21). Failure to adequately review other energy research prior to initiating a new project could result in the Commission contracting for work which parallels other ongoing or completed work.

Finally, the Commission needs to implement a system for monitoring the progress and effectiveness of its own research projects. Staff should identify effectiveness performance indicators, standards based upon project objectives, and the proper data base to measure the effectiveness of research projects. The lack of such information prevents the Commission and the Legislature from determining the research programs' effectiveness towards implementing alternative energy sources.

We recommend the Commission (1) develop specific criteria for prioritizing research programs and projects, (2) allocate resources among programs and projects consistent with its priorities, (3) clarify research project direction where necessary, (4) develop full-term project plans with time-phased milestones, (5) conduct literature searches of other ongoing and completed research prior to approving a new project, (6) establish a research advisory committee to review research plans and contracts and (7) implement a process for monitoring and evaluating research project effectiveness (see page 27).

Commission management has recently implemented some of the above recommendations (see page 30).

INTRODUCTION

In response to a resolution of the Joint Legislative Audit Committee, we have conducted an audit of the California Energy Resources Conservation and Development Commission's (Commission) management of research and development of alternative energy resources. The audit was conducted under the authority vested in the Auditor General by Section 10527 of the Government Code. This is the first of two reports concerning the Commission's operations.

The Commission, which consists of five members appointed by the Governor, is the central state organization responsible for planning and regulating electrical energy. Under California statutes, the Commission is responsible for ensuring a reliable supply of electrical energy to protect public health and safety, promote general welfare and protect environmental quality. Specifically, the statutes provide the Commission comprehensive regulatory and planning powers and duties which include (1) development of energy conservation regulations, (2) analysis of electricity supply and demand projections, (3) certification of electrical power facilities and sites, (4) coordinated planning for actions to relieve energy shortages, (5) development of safety and environmental guidelines for siting electrical power facilities and (6) administration of energy research and development programs.

To implement its programs during fiscal year 1978-79, the Commission has been budgeted approximately \$25 million and 536 staff years. The Commission funds the majority of its programs through a surcharge of 0.14 mill (\$0.00014) per kilowatt hour on electricity sold in California. (A surcharge of up to .20 mills per kilowatt hour is allowable.) The rate structure results in a larger financial contribution from those who consume the most energy. Commission budgets since fiscal year 1975-76 have been as follows:

	<u>Actual Budget</u>			<u>Estimated Budget</u>
	<u>FY 1975-76</u>	<u>FY 1976-77</u>	<u>FY 1977-78</u>	<u>FY 1978-79</u>
State	\$10,516,043	\$14,477,106	\$17,074,477	\$19,032,582
Federal	41,070	982,439	2,923,995	4,707,090
Reimbursable	<u>-</u>	<u>49,453</u>	<u>190,984</u>	<u>1,493,544</u>
	<u>\$10,557,113</u>	<u>\$15,508,998</u>	<u>\$20,189,456</u>	<u>\$25,233,216</u>
Personnel Years	200	342	489	536

BACKGROUND

Subdivision (c) of Section 25216 of the Public Resources Code mandates the Commission to "Carry out, or cause to be carried out, under contract or other arrangements, research and development into alternative sources of energy . . . which are of particular statewide importance." Additionally, the Code requires the Commission to (1) participate in demonstration projects and (2) conduct technical assessment studies on all forms of energy and energy related problems. While the Code identifies general areas for study (see Appendix A), the Commission

exercises wide discretion in determining the overall scope of research activities. Finally, the Code requires the Commission to develop and submit an integrated and prioritized program of proposed research and development and technical assessment projects. Information on project objectives, final end products, timing and progress towards completion is required on each project item.

The Executive Office's Development Division assumes primary responsibility for fulfilling the above mandates. The Division, which is budgeted approximately \$5 million, is divided into four primary offices-- Solar, Geothermal, Fuels and Special Projects (responsible for research of cogeneration and low-head hydroelectric).^{*} These offices represent the particular technologies selected by the Commission for near-term application in California. Since the Commission's inception in January 1975 the Development Division has had the following budgets:

<u>Development Division</u>	
<u>Fiscal Year</u>	<u>Expenditures[†]</u>
1975-76	\$ 2,363,906
1976-77	2,960,580
1977-78	3,508,435
1978-79	<u>4,718,300</u> (budgeted)
Total	<u><u>\$ 13,551,221</u></u>

[†] State and federal funds.

^{*} Cogeneration uses exhaust steam, waste steam, heat or resultant energy from an industrial, commercial or manufacturing process to generate electricity.

Low-head hydroelectric is any hydroelectric plant smaller than 15 megawatts.

SCOPE OF AUDIT

The audit emphasis was on reviewing the effectiveness of the Commission's system for planning and monitoring research and development of alternative energy sources. To review the Commission's management of research and development, we (1) reviewed Commission policies; (2) documented and analyzed the management process used by the Development Division; (3) studied management processes used by other public and private research firms such as the Electric Power Research Institute, the U. S. Department of Energy and the Hewlett-Packard Corporation; and (4) reviewed Commission research projects.

AUDIT RESULTS

NEED FOR INCREASED PLANNING AND MONITORING OF RESEARCH AND DEVELOPMENT OF ALTERNATIVE ENERGY SOURCES

The California Energy Resources Conservation and Development Commission (Commission) needs to develop a more comprehensive system for planning and monitoring energy research, development and technical assessment activities. During fiscal year 1977-78, the Commission spent about \$3.5 million to study alternative technologies both in-house and through contracts. To ensure that expenditures for research and development of alternative energy sources provide maximum benefits to the State, the Commission needs to modify its planning and monitoring system to include:

- Development of specific criteria for evaluating new research projects individually and prioritizing all approved programs and where applicable, projects, within those programs. Criteria should include:
 1. Potential energy to California
 2. Technological feasibility during a specific time period
 3. The amount of influence and leverage the Commission can exercise in implementing the technology
- Allocation of resources among research programs and projects consistent with priorities identified through systematic application of policy criteria

- Development of project plans which identify (1) the full life of the project, (2) an ultimate measurable objective, (3) time-phased milestones, (4) technical, economic and social performance characteristics which constitute project success and (5) total estimated cost
- Requirements to review research conducted by other organizations to avoid unnecessary duplication
- Establishment of a research advisory committee to provide input to the planning process and review projects for potential duplication
- Implementation of a formal process for monitoring and evaluating the effectiveness of research projects.

Commission management has acknowledged the need to develop a more comprehensive planning and monitoring system and has already begun (1) developing criteria for ranking research projects, (2) incorporating measurable objectives into research plans and (3) monitoring research conducted by other organizations.

Need For Improved Planning

Commission research and development of alternative energy sources has generally focused on development of program concepts.* The Commission reviewed and screened many research areas to determine

* Development of program concepts involves assessing various energy technologies and evaluating them to identify (1) the specific research program areas to pursue and (2) the general direction and methodology.

which ones should be pursued. At the conclusion of the screening period, the Commission selected primary and secondary priorities for solar, geothermal, fuels and other technologies. However, during the program development period and since identification of specific program elements, the Commission has not used a comprehensive and systematic process to prioritize and plan its research and development activities. The current planning process is insufficient to ensure maximum benefits from future resources spent on research of energy alternatives. Research and development planning requires (1) more specific policy direction and (2) improved planning of research projects through development of project plans reflecting operational objectives and time-phased milestones.

Program Policy Development

Commission authority for research and development is derived from the mandates of Section 25601 of the Public Resources Code. Since 1975, the Legislature has passed additional legislation which has helped shape Commission research direction (see Appendix B). While legislative mandates have provided direction in some areas such as solar energy, development of an integrated program of proposed research has been the Commission's responsibility.

The focus of Commission research and development has been based upon the policies, resolutions and official positions on proposed legislation adopted by the Commission. The 1977 Biennial Report serves as the Commission's principal policy statement on research and

alternative energy sources. The report's discussion of the Commission's role, research program goals and general criteria for selecting research project areas, is, however, broad in nature.

For example, according to the report, the Commission's role is to fund research and development projects which will help to solve California's own unique energy problems. Specifically, the report describes three dimensions of the State's role:

1. Joining or influencing the research efforts of private industry and other governmental agencies
2. Assuming the leadership role in areas where federal and private sector effort is less than optimal from the California viewpoint
3. Serving as a "test bed" for promoting technological and nontechnological energy innovations.

The Biennial Report also presents Commission policies on evaluating and selecting research programs. According to the report, the program must reflect:

. . . selectivity and balance in choosing projects with the highest beneficial impact on the broadest segment of the public in the shortest time; systematic evaluation to insure the maximum value from each project; flexibility to free resources to solve important new problems when they arise; and utilization of leverage to influence the direction of projects done by others . . .

Finally, the Commission's report states that research priorities have been developed on the basis of four policy questions:

1. Can the development of the option contribute to meeting California's projected energy needs in the next 20 years?
2. Does the option have controllable or negligible environmental effects?
3. Is the option sufficiently pursued by other organizations?
4. Can the Commission's support result in significant benefits to California?

While the above policies may have provided the necessary direction for reviewing and selecting the major program areas, additional and more specific policy directives are necessary to assist the Development Division in managing research and development. Currently, the Development Division relies primarily upon the budget process to select specific project areas within the program areas. Each of the Development Division's four offices annually develop project plans and associated budget proposals which are processed through the Commission's budget hearing. However, no systematic process applying specific criteria exists for evaluating research projects either individually or against one another. According to Division management, additional policy direction is necessary to (1) select the proper role and level of investment for projects, (2) effectively allocate total resources among research programs and projects and (3) decide on specific direction for certain projects. In December 1977, the Division's quarterly review reported:

The Division faces problems that at a minimum have limited its effectiveness and at a maximum have led to missed goals. . . . The Commission at all levels has not yet developed an effective mechanism for prioritizing projects.

Conversely, other government and nongovernment organizations conducting electrical energy research develop and rely upon comprehensive planning processes. To develop comparative criteria for planning and managing research and development, we reviewed the systems used by the Electric Power Research Institute and the U. S. Department of Energy.

Electric Power Research Institute (EPRI): In 1973 the utility industry voluntarily formed EPRI to conduct a broad program of research and development in technologies for electric power production, transmission, distribution and utilization. EPRI, which receives its \$155 million contract budget through a \$0.188 mills/kwh surcharge on electricity sold, is organized into four technical divisions running 35 research programs. Though the institute employs 485 individuals, none of the research is conducted in-house.

EPRI utilizes a four-part planning process functioning from a common set of planning premises or policy statements (see Appendix C.) EPRI's planning premises outline existing and projected energy conditions in the country. Future demand for energy, consumption, sources of energy, changes in society, changes in the supply pattern, as well as resource projections, are included in the assumptions. These planning premises are reviewed and updated annually by use of a modified delphi* survey questionnaire technique.

* The Delphi Method is a systematic process involving iterative questionnaires administered to individual experts. Feedback of results accompanies each iteration which continues until convergence of opinion or a point of diminishing returns is revealed. The end product is the consensus of experts including their commentary on each questionnaire item.

EPRI's planning staff coordinate input from four primary contributors to the planning process--the public, government, overseas groups and representatives of the electric utilities. The above groups are represented through a public advisory council, memorandums of understanding, information exchange agreements and a research advisory committee, respectively. These planning inputs, in varying degrees, assist EPRI in developing its overall strategic plan. Based upon the strategic plan, EPRI management identifies general funding levels for each of its research program areas. Division directors and program managers then allocate the budgeted resources among their various projects. The proposed budgets are then reviewed for approval by EPRI's research advisory committee. The decision to initiate new research projects is based on cost-benefit analysis, net energy analysis* and expert opinions on the feasibility and potential of a proposed project.

U. S. Department of Energy (DOE): Prior to DOE's formation in 1977, the U. S. Energy Research and Development Administration had assumed primary responsibility for federal energy research activities. On September 30, 1977, DOE published an interim management directive outlining its Policy and Program Planning System. According to the directive, DOE developed the system to ensure that all major organizational elements participate fully in the development and execution of research policy. Due to DOE's recent formation, the system has not yet been fully tested. The following description is based upon the above-mentioned directive.

* Net energy analysis is a systematic process for evaluating the benefits and costs of alternative energy technologies by subtracting the total energy required to mine, transport, convert, transmit, maintain, etc., a generation source from the total energy output of a source of generation.

DOE's system consists of a policy development phase, program and budget review phase and program implementation and evaluation phase. The policy development phase involves an assessment of the energy situation, the national energy plan and the effect of DOE programs. During this period, DOE receives input from (1) regional energy advisory boards; (2) public meetings where interest groups, industry and educational representatives make presentations; (3) assessments of the world energy situation; and (4) other internal energy assessments.

Based upon all these inputs, annual policy and fiscal guidance statements are prepared for the Secretary of Energy's review and approval. These statements include general fiscal guidance and program budget targets for each major program effort. Departmental line managers develop multi-year program plans which outline program objectives and strategy over a number of years. The Secretary reviews and approves the plans in the process of preparing for annual budget submission.

The forum for secretarial review and approval of budget issues and program plans is the Program Review Board. Individual program budget proposals are reviewed to (1) identify major program or policy issues, (2) identify funding, authorization, appropriation or other budget issues which require resolution prior to developing a final budget and (3) integrate the proposed budget with Office of Management and Budget planning targets. A consolidated program budget is developed and reviewed for consistency with policy and fiscal guidance statements. The Program Review Board reviews the budget prior to secretarial approval.

Both EPRI and the U. S. Department of Energy have developed comprehensive planning systems for developing policy and allocating resources. While budget size, goals, policy assumptions and program direction may differ between the two, and from the State of California's, the use of a defined process for developing policy assumptions, program priorities and resource allocations is consistent. Development of specific policy assumptions or premises, use of advisory committee input and a top-down bottom-up planning approach are major elements of the systems.

Because the Commission has only recently refined its program and project areas, the lack of adequate policy direction and evaluative criteria for prioritizing projects has had minimal effect. However, the above discussed conditions have resulted in a research program in which (1) a small research budget (in comparison to EPRI and DOE) has been spread over 15 project areas and 84 contracts and (2) program areas with the highest projected energy potential for the State are receiving the smallest portion of the budget.

During fiscal year 1977-78, the Commission allocated its approximately \$3.5 million (\$1.9 million in contracts) Development Division budget among 15 project areas (see Table 1, page 16). Within these project areas, 84 contracts have been sponsored. In comparison, EPRI's research project budgets range from \$25,000 to \$40 million each.

TABLE 1
ALTERNATIVE ENERGY RESEARCH
PROJECT BUDGETS

<u>Project</u>	<u>FY 1977-78</u> <u>Contract Budget</u> <u>(State Funds Only)</u>
Solar:	
1. Passive Thermal Space Conditioning	\$ 180,000
2. Solar Water Heating	185,000
3. Solar Electric Generation (Solar electric and wind electric)	190,000
4. Consumer and Professional Services for Solar Market Expansion	120,000
5. Technical Programs for Market Expansion	50,000
6. Economic Analysis, Planning and Governmental Programs	<u>100,000</u>
Subtotal	<u>\$ 825,000</u>
Geothermal	
7. Geysers	\$ 105,000
8. Imperial Valley	50,000
9. Direct Heat Applications	-0-
10. Planning and Implementation	<u>85,000</u>
Subtotal	<u>\$ 240,000</u>
Fuels	
11. Coal	\$ 160,000
12. Biomass	320,000
13. Policies	<u>80,000</u>
Subtotal	<u>\$ 560,000</u>
Energy Systems Integration	
14. Future Energy Alternatives	\$ 190,000
15. Systems Assessment	<u>120,000</u>
Subtotal	<u>\$ 310,000</u>
TOTAL	<u><u>\$1,935,000</u></u>

Although the Commission has estimated the potential for up to 14,000 megawatts of energy from California's geothermal resources, projects devoted to geothermal research receive only 12 percent of the Development Division's budget (state funds). The former manager of the Geothermal Office estimated that funding levels 10 to 100 times the fiscal year 1978-79 budget would be required over a three-year period (amount depends on available federal funds) to do materially more towards implementing geothermal power in California (successful implementation of geothermal power is also dependent upon other entities). During fiscal year 1977-78, the Geothermal Office had 12 staff and a state project contract budget of \$240,000.

Currently, the Commission allocates the largest amount of its Development Division budget to research and implementation of solar energy. While solar research receives more than twice as much money as the fuels from biomass* budget, the Commission, in its 1977-78 project plan (See Appendix C), projected solar to have a significantly smaller potential energy payoff for California. Although the Commission has estimated potential energy for various technologies, it has not formally applied this information in prioritizing programs and allocating resources.

While research program priorities cannot be determined based only on a single criterion such as potential energy, it is necessary to identify the specific set of criteria to be used in evaluating and

* Biomass is organic material such as trees, plants, manure and various agricultural and forestry wastes transformed into a variety of clean forms of fuels which can be used to produce electricity and heat and transportation fuels in substitution for conventional, nonrenewable energy sources.

prioritizing programs and projects. Without such criteria and a process for applying them, there are no assurances that resources will be allocated among those projects with the greatest potential benefit to California.

More specific policies are necessary to avoid constraints to the development of energy alternatives. As the Commission has continued to refine its research programs, occasions have arisen where policy direction would have helped facilitate research program planning and budgeting.

For example, during the Geothermal Office's initial development, Commission policy direction on geothermal programs was limited to responses to initiatives presented at budget hearings. In March 1978, the Commission adopted a policy which removed ambiguities in the procedures for licensing geothermal power plants and reduced the processing time by six months. According to the previous manager of the Geothermal Office, the regulatory process for licensing geothermal power plants could have been adopted one year earlier had the Commission provided policy direction at an earlier date.

Research decisions requiring policy direction will continue to occur in the future. For instance, the Commission's fuels from biomass program will reach a state where further development could take at least two directions--conversion of biomass into alcohol-fuel or direct electricity. According to the manager of the Fuels Office, a Commission policy decision will be necessary to clarify research direction. Additionally, the Commission will need to decide the State's role in development of major biomass demonstration projects, the level of state investment and whether to share the cost with the private sector.

Throughout the course of the audit, we briefed the Commission on our tentative findings. Commission management concurred that specific criteria need to be developed to evaluate and prioritize program areas and projects. Based on our recommendation, the Commission, in August 1978 invited representatives from utilities, industry, other government organizations and public interest groups to participate in developing criteria for the fiscal year 1979-80 budget. With assistance from these groups, the Commission is currently developing criteria to be used in evaluating potential projects.

Project Planning System

With the Commission's refinement of research program concepts and direction, it is increasingly necessary to conduct planning on a project basis, reflect quantifiable objectives and identify time-phased milestones. Currently, Commission research projects are planned on one-year cycles and generally do not outline the ultimate objectives. As a result, the Commission is unable to (1) accurately estimate total project costs and time frames and (2) monitor progress and effectiveness.

During fiscal year 1977-78, the Commission funded 15 different projects within four program areas. A review of 14 Development Division project plans revealed that only six projects attempted to outline quantifiable objectives which reflected projected results. Four of the six projects identified long-term objectives but did not identify interim milestones. Each research project plan outlined the specific tasks to be accomplished and their costs during the fiscal year,

but generally did not (1) identify the total project life, (2) specify quantifiable objectives or results to be achieved or (3) outline the time-phased milestones.

Conversely, other public and private research organizations plan research efforts on a project basis. EPRI, prior to approving a new project area, develops a specific plan for the life of the project. The plan outlines ultimate objectives and each of the interim steps towards their accomplishment.

The U. S. Department of Energy develops multi-year research plans which sequence the total research process into discrete steps and specify the decision points at which technical and performance characteristics will be evaluated. To the extent possible, each plan (1) estimates the total cost of the program and the potential benefits, (2) describes the relation of the effort to related activities in the private sector, (3) specifies the technical and economic performance characteristics which would constitute program success and (4) indicates the probabilities of technical success for each discrete step of the research process.

Development Division management concurs that research planning should be conducted on a project rather than an annual basis. Furthermore, the Division administrator believes plans should include more quantifiable objectives and time-phased milestones. While multi-year plans may not have been necessary until program concepts and

direction were sufficiently refined, current and future projects should identify objectives and time frames which will enable both the Commission and the Legislature to monitor project progress.

Need For Increased Project Monitoring

The Development Division needs to implement a formal system for monitoring (1) research and development conducted by other organizations and (2) the progress and effectiveness of its own research projects. As research program areas and specific projects have become increasingly refined, the need for a monitoring system has surfaced. Currently, no formal system exists for monitoring project progress and effectiveness and only recently has a requirement to review other research activities prior to project approval been implemented.

Review of Other Energy Research

Subdivision (d) of Section 25216.5 of the Public Resources Code requires the Commission to serve as a repository for information on energy research. To fulfill this requirement, the Commission has established computerized access to 16 data bases providing a comprehensive survey of research in the energy field. While these data bases could serve as a valuable tool for monitoring energy research and development, the Development Division has seldom used the system to review other research activities prior to initiating a new project.

Energy research and development is conducted by hundreds of organizations including electric utilities, universities and nonprofit organizations. While there is no single reference for all energy research projects, there are many government and private data bases which record both completed and ongoing research. For instance, EPRI maintains a data base of all research being conducted by private utilities, as well as information on foreign energy research projects. The Commission relies upon the U. S. Department of Energy's RECON data system which consists of 16 different data bases recording over 1.7 million citations of both completed and ongoing projects.

According to Commission management there has been no requirement in the past to conduct a computer search of other research and development prior to initiating a new project. Rather, Development Division management has delegated to the individual project managers the responsibility of ensuring that Commission projects do not duplicate other work. Based on an Auditor General questionnaire and interviews with staff, we found that Development Division staff have only used the Commission data bases on two occasions. Generally, management relies upon staff knowledge of research activities based upon contacts with other research organizations and review of pertinent journals. While staff may be aware of a significant amount of energy research in a specific field, almost exclusive reliance upon staff knowledge does not ensure projects will not duplicate other work.

In addition to reliance on data bases to stay abreast of research activities, other research organizations such as EPRI, DOE and the Air Resources Board have established committees to review and approve proposed research projects.

For example, Section 39705 of the Health and Safety Code requires the California Air Resources Board to establish a committee to review all research activity. The committee consists of nine individuals from various parts of the scientific community. Principally, the committee (1) provides input on development of research project areas for the Board's \$3.2 million budget, (2) reviews all research contract requests for proposals and (3) reviews staff contractor proposal bid evaluations and selects a contractor for Board approval.

Failure to adequately review other energy research prior to initiating a new project could result in the Commission contracting for work which parallels other ongoing or completed research. While parallel research may produce useful and beneficial products, the cost may outweigh the benefits when balanced against the opportunity cost of other projects and a limited budget. Although our audit identified no Development Division contracts which duplicated other research, a review of a sample of contracts awarded by the Commission revealed at least one contract which partially paralleled other work.

In March 1976, the Commission awarded a \$60,000 contract to the Lawrence Livermore Laboratory (LLL) (through the Energy Research and Development Administration). Specifically, the contract required (1)

compiling major recent studies on California oil, gas and uranium reserves and reserve depletion, (2) summarizing and assessing the method used to estimate additional remaining resources, (3) forecasting depletion prospects under various methodologies and (4) identifying further research, sources of estimates, etc.

Portions of the contract paralleled data maintained and reported annually by the California Department of Conservation, Division of Oil and Gas. According to the State Oil and Gas Supervisor, his division maintains the most accurate, complete and up-to-date information on California's oil and gas production and well records available. The Division's publications, combined with those of the Committee of California Oil Producers, make up one of the most complete and detailed collections of field and pool performance and reserve statistics in existence. These data could have been available to the Commission upon request. The Supervisor also noted that there was some inaccurate information reported in the LLL study.

During the course of our audit, we briefed the Commission's executive management on the above conditions. Commission management concurred with our conclusions and in July 1978 adopted a policy requiring a literature search prior to awarding any product-oriented contract. Development Division staff, in response to our discussions regarding peer review committees, are establishing a research advisory committee to function in a review capacity.

Effectiveness Measurement

The Development Division needs to implement a process for evaluating the effectiveness of its research projects. While the Division has historically gathered and reported progress on its projects, effectiveness has been measured in terms of project inputs rather than outputs. As a result, neither the Commission nor the Legislature can determine progress towards actual implementation of alternative energy sources.

As previously discussed, research projects are planned on an annual basis. While general objective statements and specific tasks to be accomplished are outlined, overall objectives and time-phased milestones are not identified. For example, the Commission's project entitled "Electricity Systems" states that its purpose, in part, is to:

Provide the State with solar-based central and dispersed electric power generation alternatives . . . Develop strong wind resource knowledge base in California by assessing status of wind-electric conversion technology, conduct "wind prospecting" and data collection at promising sites . . .

The project products are to include (1) an assessment of the most promising wind sites in California and (2) development and definitions for siting and implementing solar thermal electric technology. The Commission reported its fiscal year 1977-78 progress as (1) completion of first-phase studies on wind resource assessment and (2) initial assessment of wind technology.

While this research activity may be totally justified and appropriate, there is no quantifiable statement of the project's objective. Total project elements, cost and schedules for completion are not identified. Project progress is evaluated in terms of completed tasks rather than advancement towards an objective or some level of implementation.

As previously discussed, other research organizations such as EPRI and DOE develop overall project plans outlining specific objectives and time-phased milestones. Periodically, their management reviews project performance against scheduled milestones to evaluate effectiveness.

Measuring the effectiveness of research projects is difficult due to the long time frames and uncontrollable variables involved. Additionally, effectiveness cannot be adequately measured until specific project direction has been set; a stage which the Commission has only recently reached. However, unless the Commission develops performance indicators, standards based upon its objectives and a data base to measure, neither it nor the Legislature will know how effective it is in implementing alternative energy systems within certain time frames. Additionally, the absence of this information will make decisions regarding future research projects more difficult.

CONCLUSION

The California Energy Commission needs to develop a more comprehensive system for planning energy research, development and technical assessment activities. To date, Commission research of alternative energy sources has generally focused on development of program concepts. To ensure that expenditures for research and development of alternative energy sources provide maximum benefits to the State, the Commission needs to develop (1) more definitive policies and criteria for evaluating and prioritizing research projects and (2) multi-year project plans which include quantifiable objectives, time-phased milestones and total project cost estimates.

Additionally, the Commission needs to implement a formal system for monitoring (1) research and development conducted by other organizations and (2) the progress and effectiveness of its own research projects.

RECOMMENDATION

We presented our conclusions and recommendations to the Commission's executive management. After review, Commission management concurred with the recommendations shown below. Some of the recommendations were co-authored by Commission management.

To improve the management of research and development of alternative energy sources, we recommend the Commission develop a more systematic process for planning and monitoring research of alternative energy resources. Specifically, Commission management and staff should:

1. Develop specific criteria for evaluating new research projects individually and prioritizing all approved programs and projects. Criteria to be considered should include, but not be limited to, (1) potential energy available to California, (2) technological feasibility during the next 20 years, (3) the emphasis and scope of research being conducted by other organizations, (4) the amount of leverage the Commission can exercise over implementation of the technology and (5) the level of interest among private industries and utilities. Management should utilize an operational method of applying the criteria
2. Allocate resources among research programs and projects consistent with their priorities as determined by a systematic application of evaluative criteria
3. Develop specific policy options for Commission consideration early enough in the budget cycle to allow for proper discussion and effective development of project plans and budgets

4. Plan research on a project life basis. Where appropriate, multi-year plans should be developed. Plans should state quantifiable objectives which (1) utilize time-phased milestones, (2) identify specific results to be achieved, (3) specify the technical, economic and social performance characteristics which will constitute project success and (4) identify total estimated project cost
5. Require a literature search of completed and ongoing research (related to the specific project) prior to initial project approval. Follow-up literature searches should be conducted annually prior to submission of each new fiscal year budget
6. Establish a research advisory committee to (1) provide input on planning of research projects, (2) review research project plans and (3) function as a peer review for research contracts awarded by the Commission. Committee membership should include individuals from the general research field--only a portion of the members should come from the energy field. The Commission should identify a contract dollar level to distinguish contracts to be reviewed

7. Implement a process for monitoring and evaluating the effectiveness of research projects. Performance indicators, standards based upon project objectives and proper data bases for measurement should be identified. While ultimate results may not be observed for many years on some projects, interim progress should be monitored and reported to the Legislature.

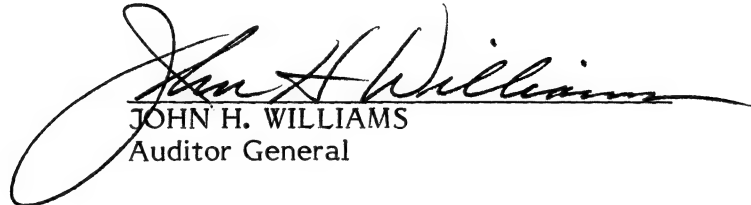
Corrective Action By The Commission

During the course of the audit, we periodically briefed Commission management and staff on tentative conclusions and recommendations. Commission management concurred with our results and implemented many recommendations prior to audit completion. Specifically, the Commission:

1. Conducted workshops, held informal meetings and reviewed other research organization planning systems. Based upon this work, the Development Division has drafted (1) criteria for screening potential research projects and (2) criteria for ranking projects. Those criteria were used in developing the proposed fiscal year 1979-80 Development Division budget
2. Adopted a policy requiring research literature searches prior to contract approval.

Additionally, the Commission is in the process of (1) establishing a peer review advisory committee and (2) developing research project plans which include measurable objectives.

Respectfully submitted,



JOHN H. WILLIAMS
Auditor General

November 17, 1978

Staff: Harold L. Turner, Audit Manager
Richard C. Mahan
Kathleen A. Herdell
Peter Wolfe

CALIFORNIA ENERGY COMMISSION

1111 HOWE AVENUE
SACRAMENTO, CALIFORNIA 95825
(916) 920-6103



November 16, 1978

Mr. John Williams, Auditor General
Joint Legislative Audit Committee
Office of the Auditor General
925 L Street, Suite 750
Sacramento, CA 95814

Dear Mr. Williams:

This letter responds to a draft report of your office to the Joint Legislative Audit Committee titled Improvements Needed in Planning and Monitoring Research and Development of Alternative Energy Sources dated November 1978. We are grateful for the professional manner and constructive approach of the audit team assigned to this project and commend it to you as an ideal model for future audits.

As the report acknowledges, we concur with the results and have implemented many of the recommendations prior to audit completion. We are also implementing or plan to implement all of the remaining recommendations. The draft report contains the actions we have already taken. As suggested by the audit team, details on what we have done subsequent to the audit to implement its recommendations will be contained in our response to the final report.

The audit coincided fortuitously with a change in the management of the Development (formerly Alternatives) Division.* This change enabled both the audit team and the new division management to constructively review past project and contract activities without prejudice and to openly share insights and concerns. This interaction produced important changes in our planning and administration of energy research and development as well as changes in the auditor's original analysis.

The draft report states that "the Commission has not used a comprehensive and systematic process to prioritize and plan its research and development activities." (p. 9) While we will not argue the terms "comprehensive" and "systematic", we acknowledge that this process needs to be made more explicit

*The changes included the Division Chief, the Deputy Division Chief, and two of the four office managers.

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than it has in the past. We also would hope that the audit team's final report will not raise any false expectations that the energy R&D project prioritization and selection process can be reduced to a simple algorithm or mathematic formula. We believe the audit team understands that this process is, at best, a subjective best guess--sometimes intuitive--on the part of technical experts, management, and informed decision-makers who use good judgement. What is important is that the decision criteria and process be made more explicit to provide accountability and effectiveness measurement.

To develop comparative criteria for planning and managing research and development, the audit team reviewed the systems used by the Electric Power Research Institute (EPRI) and the U.S. Department of Energy. While we agree that these institutions provide excellent models for research and development planning processes, we believe it important to note that there are large differences between their missions, clients, and resources and that of the Energy Commission. These differences can explain why the Commission uses different criteria and weights these criteria differently in the project selection process. For example, the main purpose of EPRI is:

"To provide improved technologies that can be applied to meet the needs of existing systems and to foster development of advanced alternatives for expansion of the systems to meet growing demands for electricity, thus minimizing future capital and operating costs to benefit both utility and the rate payer."

The Commission, on the other hand, has a general rather than an "electricity specific" energy R&D mandate and must take social and environmental costs and benefits (as opposed to only capital and operating costs) into consideration in the allocation of its resources.

It should also be noted that the Department of Energy and EPRI have much larger budgets than the Energy Commission. (See Figures 1 and 2 attached) Their budget and project selection process need not emphasize the importance of "leverage, timing and opportunity", while this is almost paramount for the Energy Commission given its more limited funds.

The draft report suggests that at least five criteria be considered for evaluating new research projects individually and for prioritizing all approved programs and projects. We agree with these and added many more in determining

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our FY 79-80 budget. A full list of these will be included in our Energy Research and Development Report to the Legislature this year as well as in our response to your final report.

Thank you for the opportunity to respond.

Sincerely,

A handwritten signature in dark ink, appearing to read "James A. Walker". The signature is stylized with a large, prominent "J" and "W".

JAMES A. WALKER
Executive Director

Attachment

RAS:sy

FIGURE 2

COMPARISON OF TOTAL AMOUNT OF MONEY SPENT ON
NEW TECHNOLOGIES R&D

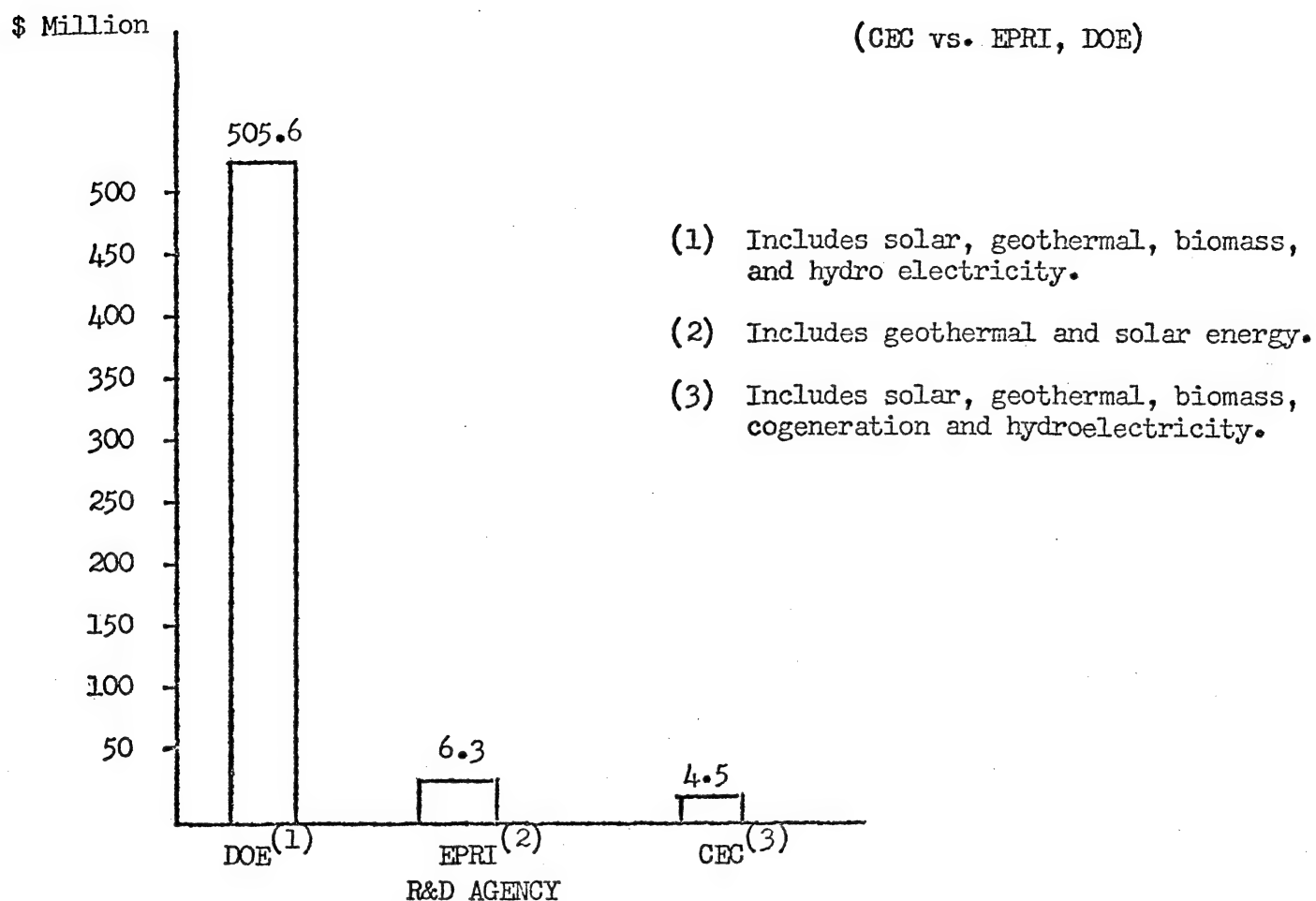
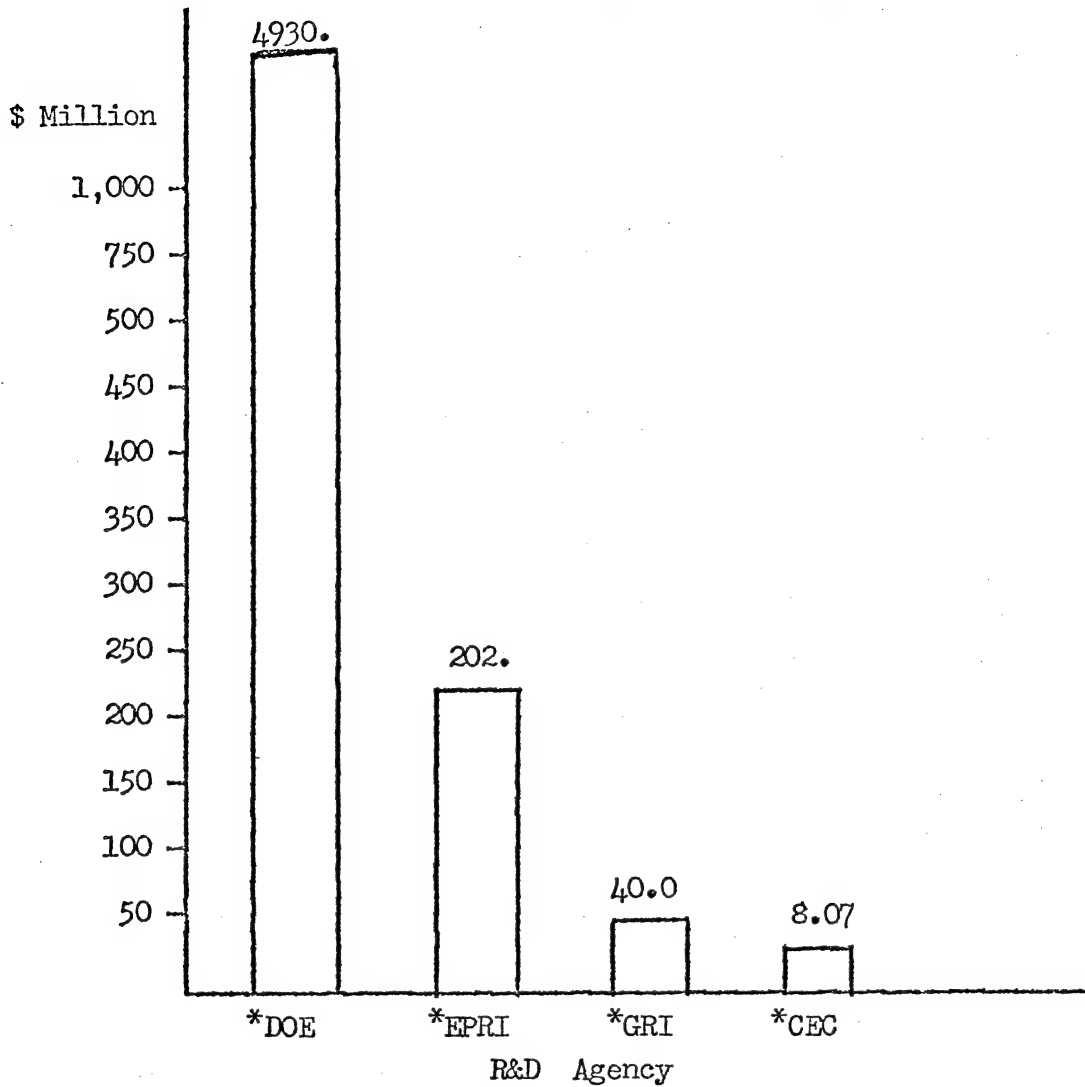


FIGURE 1

COMPARISON OF TOTAL CEC R&D BUDGET WITH MAJOR
NATIONAL R&D PERFORMERS



*Department of Energy (DOE)

Electric Power Research Institute (EPRI)

Gas Research Institute (GRI)

California Energy Commission (CEC)

LEGISLATION RELATING TO COMMISSION
RESEARCH OF ALTERNATIVE ENERGY SOURCES

Solar Legislation

1. AB 2841 (Mello, et al.) -- Chapter 1091, Statutes of 1978

This bill requires the Employment Development Department and the Energy Commission to study the employment opportunities in the energy sector for economically disadvantaged persons and to report their findings to the Legislature.

The Commission supported this bill.

2. AB 2976 (Mello) -- Chapter 1089, Statutes of 1978

This bill requires the Energy Commission to establish a state wind energy program to speed the commercialization of wind electric systems. \$800,000 would be appropriated from the Commission's Reserve Account to fund this program.

The Commission supported this bill.

3. AB 3046 (Rosenthal) -- Chapter 1367, Statutes of 1978

This bill requires the Energy Commission in conjunction with the Office of the State Architect to establish a statewide competition to select outstanding examples of residential architecture that incorporate passive solar features. \$315,000 would be appropriated from the Commission's Reserve Account to conduct this program.

The Commission supported this bill.

4. AB 3324 (Wornum) -- Chapter 1155, Statutes of 1978

This bill requires the Energy Commission to develop a solar implementation plan to be part of the Biennial Report.

The Commission supported this bill.

5. AB 1512 (Chapter 1081, 1977)

This statute requires the Energy Commission to develop and adopt solar energy equipment standards and specifies provisions to enforce them. In addition, this statute requires the commission to develop designs and specifications for prototype housing using passive thermal systems, and to develop a manual of design types, costs, performance and evaluation procedures for passive thermal systems. The Commission supported this bill.

6. AB 1558 (Chapter 1082, 1977)

This statute extends the income tax credit to the lesser of 55% or \$3,000 of the acquisition costs of a solar energy system, including certain conservation measures. In addition, this statute allows unused portions of the credit to be carried forward to future years and requires the Energy Commission to establish guidelines and criteria for solar energy systems eligible for the credit. The Commission supported this bill.

7. SB 150 (Chapter 773, 1977)

This statute requires the Energy Commission to develop guidelines and cost analyses to enable the public to compare life cycle costs of various building design alternatives. In addition, this statute requires specified, new state-owned structures to be equipped with a supplementary solar water heating system, unless exempted by the State Architect. The Commission supported this bill.

8. SB 373 (Chapter 1, 1978)

This statute creates a solar energy loan fund to finance residential solar installations in dwellings damaged or destroyed by a state declared disaster. Eligible solar energy systems must meet criteria established by the Energy Commission. The Commission supported this bill.

Geothermal Legislation

9. AB 2644 (Goggin, et al.) -- Chapter 1271, Statutes of 1978

This bill streamlines the permit process for geothermal field development and exploratory projects and would revise the Commission's NOI/AFC procedures and time schedules for geothermal powerplants.

The Commission supported this bill.

10. AB 3707 (Kapiloff and Goggin) -- Chapter 1270, Statutes of 1978

This bill provides that geothermal exploratory, development and production wells are not subject to powerplant certification by the Energy Commission, revises present law governing the disposal of solid and liquid wastes from geothermal resources drilling, redefines "private energy producers" for electricity wheeling purposes, and makes other changes in law related to geothermal energy.

The Commission supported this bill.

Fuels Legislation

11. SB 2066 (Rains) -- Chapter 1008, Statutes of 1978

This bill establishes guidelines for developing and funding a coal gasification demonstration project. The Energy Commission shall evaluate such projects and is authorized to negotiate with public or private entities to support the construction of the demonstrations. In addition, this bill eliminates the NOI and reduces the AFC to 12 months for a coal gasification combined cycle demonstration plant not exceeding 300 megawatts.

The Commission supported this bill.

12. AB 3032 (Keene and Calvo) -- Chapter 1009, 1978

This bill specifies that ownership or operation of a facility using a cogeneration technology does not make a person a public utility solely because of the ownership or operation of such a cogeneration facility. In addition, this bill provides that a corporation or person may employ cogeneration technology in the generation of electricity for a corporation or state or local public agency without becoming subject to the jurisdiction of the PUC.

The Commission supported this bill.

13. SB 1805 (Holmdahl) -- Chapter 1010, 1978

This bill defines cogeneration technology and streamline the Energy Commission's review process for powerplants not exceeding a 300 megawatts that use cogeneration technologies. The NOI would be eliminated and the AFC would be limited to a one year time frame. In addition, the same streamlined review process would apply to:

1. A thermal powerplant for which only one site is feasible
2. A thermal powerplant with a generating capacity of up to 100 megawatts
3. A thermal powerplant designed to develop or demonstrate renewable or alternative technologies not exceeding a capacity of 300 megawatts
4. A modification of an existing powerplant.

The Commission supported this bill.

ELECTRIC POWER RESEARCH INSTITUTE
PLANNING PREMISES

The following are excerpts from EPRI's "Outline of Critical Factors Affecting EPRI Research and Development."

Total U. S. Energy Needs

The average annual growth rate for total energy consumption over the next quarter century is expected to lie in the range between 2.4% and 3.4% per year. In the year 2000, the nation's requirement for all primary energy resources, including oil, gas, coal, uranium, solar, geothermal and hydropower is expected to be between 128 and 162 quads.*

Electricity Consumption

The average annual national growth rate for electricity consumption is anticipated to be between 4.1% and 6.5% over the period from 1975 to 2000. A lower growth rate, in the range from 2.8% to 3.8%, is projected for the first 20 years into the next century. Electricity consumption at 7.5 trillion kWh in the year 2000 is the nominal target figure for research planning. For comparison, electricity consumption in 1976 was approximately 2 trillion kWh.

Electricity Conservation Effects

The range of electricity consumption figures used by EPRI for planning includes an estimate for the effects of voluntary and price-induced energy conservation. The nominal electricity planning target (7.5 trillion kWh in 2000) is consistent with an average conservation-induced reduction of 17% from electricity requirements projected using historical experience.

Capacity Expansion

Total electric utility capacity requirements in the year 2000 are expected to lie between 1200 and 1800 GW. The year 2000 planning target of 7.5 trillion kWh (consumption) translates into a capacity requirement of 1680 GW, approximately three times the nation's installed capacity in 1976.

- Hot water geothermal and solar thermal generating plants are the only new energy sources that can make some contribution to the production of electricity in the remainder of this century.

* 1 quad = 10^{15} BTU.

- The projected solar capacity optimistically assumes that by 2020 central receiver solar thermal plants will capture approximately 60% of the intermediate load in those areas of the country suitable for solar-thermal installations. Approximately one thousand 100 MWe solar-thermal plants would be required to meet this load. Analyses indicate that solar central-receiver (power tower) plants are most likely to become the first commercially economical solar power plant type, perhaps by 1995, and then only for intermediate service which closely matches sunlight availability. Assuming an optimistic construction schedule, perhaps ten 100 MWe plants may be operating by 2000.
- Advanced solar (photovoltaic, wind, biomass, ocean thermal gradients, etc.) fusion and other advanced systems will not supply any substantial quantities of energy by the year 2000.
- Utilization of waste products could supply energy up to a maximum of perhaps 3% of total electric energy requirements, but shall most probably be less than 1% in the year 2000.
- Only limited quantities of natural gas and petroleum will be available for utility use in the year 2000. As a capacity target, it is assumed that natural gas and petroleum-fired capacity will not exceed 200 GW and will generate not more than 390 billion kWh in that year. It should be recognized that this is a planning assumption only. If coal and nuclear plant expansion is seriously hindered, expansion of oil and gas plants is the only viable generation alternative available to utilities.

Fuel (Primary Resources) Availability

- Approximately 90% of the electricity requirements in the year 2000 will be generated using uranium and coal. In 1975, 53% of the nation's electricity was generated using these two resources.
- The lifetime uranium (U_{308}) requirements for the nominal 500 GW of nuclear capacity assumed to be in place by the year 2000 (see Figure 10) are 2.1 million tons (assuming fuel reprocessing). The economically recoverable domestic uranium supply is estimated to be between 1.8 and 3.5 million tons, with about 700,000 tons of now proven reserves.
- The research plan assumes that total coal production will increase to 2.2 billion tons by the year 2000. In that year, approximately 80% (1.7 billion tons) of the coal will be required for electricity generation.

- Beyond the year 2000, oil, gas, uranium, and coal requirements for both electric and nonelectric uses are projected to exceed the capability to supply these resources. New options such as the breeder reactor, advanced solar power, advanced geothermal and fusion power must be available early in the 21st century to ensure that the electric utility industry will be able to meet the anticipated demand for electricity.

Economic and Financial Issues

New capacity required for future electricity generation, transmission and distribution will place a significant capital burden on the utility industry. Costs of electricity will increase as a result of higher fuel costs and additional capital costs for environmental control.

Environmental Requirements

For the foreseeable future the environmental requirements on electric utility systems will become more stringent.

Regulatory Issues

Nuclear regulatory requirements will dictate continued emphasis on research addressed to nuclear safety assurance, fuel reprocessing, and nuclear waste management issues.

APPENDIX C

ALTERNATIVE ENERGY SYSTEMS FOR CALIFORNIA

ALTERNATIVE ENERGY TECHNOLOGY	ENERGY EQUIVALENT OF RESOURCES IN CALIFORNIA WITHOUT REGARD TO RELIABILITY	EXAMPLE KEY BARRIERS	POTENTIAL ENERGY AVAILABLE TO CALIF.	
			(Trillion Btu/year) ⁽¹⁾ 1985	(Trillion Btu/year) ⁽²⁾ 1995
<u>SOLAR ENERGY</u>	2,500,000			
o <u>Direct-heat applications</u>				
o In buildings		o High initial cost o Regulated natural gas cost o Resistance to change by designers and builders	6-120	12-300
o For process heat		o High initial cost o Low alternate fuel cost o Data gathering and dissemination o Lack of solar engineers	4-16	8-64
o <u>Electric generation</u>				
o Solar-thermal electric		o High capital cost o Design problems o Manufacturing problems o Lack of storage technology	3-15 (100-500 Mw)	60-300 (2000-10000 Mw)
o Wind electric	1,500 (40,000 Mw)	o Lack of utility interest	6-15 (200-500 Mw)	60-3000 (2000-10000 Mw)
<u>GEOTHERMAL ENERGY</u>	34,000			
o <u>Direct-heat applications</u>		o Mitigation of environmental impacts o Establishing customer confidence in economics o Demonstrating technologies and economics o Resolving land use conflicts	1-5	5-20
o <u>Electric generation</u>		o Mitigation of environmental impacts o Establishing customer confidence in economics o Demonstrating technologies for hot water o Resolving land use conflicts	120-180 (2000-3000 Mw)	300-840 (5000-14000 Mw)
<u>FUELS FROM BIOMASS</u>	10,000	o Lack of demonstrated technologies o Regulated natural gas cost o Identification and education of potential users	150-250	1000-1500
<u>FUELS FROM COAL AND OIL SHALE</u>	Negligible	o High commercialization costs o Environmental impacts o Demonstration of technologies	0-6 (0-100 Mw)	300-900 (5000-15000 Mw)
<u>FUEL CELLS</u>	Uses any hydrogen-rich fuel	o Uncertainty of hydrogen-rich fuel availability o Lack of demonstration of costs, lifetime efficiencies o Uncertainty of potential market o Lack of capital investment to allow for mass production	3-6 (100-200 Mw)	90-210 (3000-7000 Mw)

(1) 1 Trillion Btu = 10^{12} Btu.

(2) All potential energy has been expressed in Trillion Btu/year which is a measure of heat energy. To convert electric capacity into "heat equivalent", the following assumptions were made: (a) 10,000 Btu/kWh heat rate; (b) solar, wind and fuel cell plants operate @ 3,000 hours/year; (c) geothermal and coal plants operate @ 6,000 hours/year. California's total energy consumption in 1975 was approximately 6,300 Trillion Btu.

The capacity for electric generation is shown in parenthesis. California's electric capacity in 1975 was approximately 35,000 Mw.

Source: New Resources and Technologies Program Plan; California Energy Commission, January 1978.

Office of the Auditor General

cc: Members of the Legislature
Office of the Governor
Office of the Lieutenant Governor
Secretary of State
State Controller
State Treasurer
Legislative Analyst
Director of Finance
Assembly Office of Research
Senate Office of Research
Assembly Majority/Minority Consultants
Senate Democratic/Republican Caucus
California State Department Heads
Capitol Press Corps